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BRIEFING ON FUEL CYCLE AND WASTE
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PUBLIC MEETING

Nuclear Regulatory Commission
One White Flint North
Rockville, Maryland

Tuesday, July 19, 1994

The Commission met in open session, pursuant to notice, at 10:00 a.m., Ivan Selin, Chairman, presiding.

COMMISSIONERS PRESENT:

IVAN SELIN, Chairman of the Commission
KENNETH C. ROGERS, Commissioner
E. GAIL de PLANQUE, Commissioner

STAFF AND PRESENTERS SEATED AT THE COMMISSION TABLE:

JOHN HOYLE, Acting Secretary

KAREN CYR, Office of the General Counsel

CLAUDE MANDIL, Director General for Energy and Natural Resources, Ministry of Industry

JEAN-LOUIS RICAUD, Director, Industrial Branch (COGEMA)

PHILIPPE SAINT-RAYMOND, Deputy Director, DSIN

YVES KALUZNY, Director, ANDRA (National Nuclear Waste Authority)

NOEL CAMARCAT, Director, Nuclear Fuel Cycle Division (CEA) (Atomic Energy Administration)

P-R-O-C-E-E-D-I-N-G-S

10:00 a.m.

CHAIRMAN SELIN: Good morning, ladies and gentlemen.

We're doing something somewhat unusual this morning. The Commission is getting what amounts to a briefing on a set of programs of great general interest to us, although not necessarily a direct part of our domestic regulatory responsibilities.

We're pleased to welcome Mr. Claude Mandil, the Director General for Energy and Natural Resources in the Ministry of Industry of the French Republic, and his associates. Mr. Mandil and the team will brief the Commission on fuel cycle and waste management activities in France.

France has developed a full nuclear fuel cycle in a technically impressive and professionally competent manner and in a way that differs in some significant fashions from the American philosophy. We greatly appreciate your making this special trip to the United States to describe your current activities, accomplishments and future plans. We look forward to receiving your briefing.

Commissioner Rogers?

COMMISSIONER ROGERS: Thank you very much.

CHAIRMAN SELIN: Mr. Mandil, the floor is yours. Thank you.

MR. MANDIL: Thank you very much, Mr. Chairman, ladies and gentlemen. It's really a pleasure and I deeply appreciate the opportunity I have today to present France's nuclear fuel cycle policy to your Commission. I will try to be very brief.

I would like to have one opening remark, which is to recall that obviously France and the United States have a quite different energy situation as France has almost no fossil fuel domestic resources and that means to a quite different energy policy which is evident. We decided a long time ago to have a strong energy policy dedicated to self -- to safety of supply, to security of supply and for the long-term. We thought that resulted in first a strong nuclear policy and, second, a nuclear until the end of the cycle. I understand it's very different in the United States, mainly because of your very abundant fossil fuel resources.

(Slide) May I have the first chart, please, which is only to tell you what -- how my presentation will be made. First, one or two minutes of nuclear energy in our country. Second, I will

speak on waste management policy, and third, on reprocessing, recycling and plutonium management, but not in detail. The details will be given by my colleagues.

First, the status of nuclear energy in France. France's nuclear program currently consists of 54 pressurized water reactors, all based on standard designs. The second chart shows you where they are in France. Sorry it's not very clear to see. These units have an installed generating capacity of close to 60,000 megawatt, electric megawatt, and generate over 75 percent of electricity produced in France. Since 1993, the units have operated with a greater than 80 percent availability factor and four more units are under construction. The units are, you can see them, in Savoie (phonetic) and Chooz.

Second main topic, waste management policy. Ninety percent of the nuclear waste generated in France is short-lived and low and medium level waste. This waste is disposed of at the Centre de la Manche and the Centre de l'Aube facilities operated by ANDRA. Yves Kaluzny is the Director of ANDRA. The Centre de la Manche facility is full now. The last waste deliveries were made last week, I think. The Centre de l'Aube facility has enough capacity to cover

disposal requirements for the next 40 years. This type of disposal facility has never raised, I must say, any problems either in terms of technology in safety, neither in terms of public acceptance as well.

For the long-term and high level waste, our approach is defined by the Waste Act of December 30, 1991 --

(Slide) Next chart, please.

-- which is an important act. Sorry for some mistakes in English. That act was passed almost unanimously by the French Parliament. This law requires that research on long-lived and high-level waste management be divided into three areas: first, separation and transmutation of long-lived radioactive elements; second, the potential for disposal in deep geological formations through construction of underground research laboratories; and third, surface storage of waste and the containment issues that this raises.

These research programs are funded by the government and the waste generators. In 1994, spending on the three research programs will be approximately 260 million, 500 million and 170 million francs respectively.

The Waste Act requires that the research

findings be presented to Parliament in 15 years. That means before 2006, accompanied by a draft repository licensing bill if the findings so dictate. Mr. Kaluzny and Mr. Camarcat will discuss the work being conducted in the framework of the Waste Act in more detail. What I can say is the problems are not solved, the problems are difficult, more difficult in high-level waste management than in low and medium grade. But we have a strong political support by that framework which is that act which was passed by the Parliament without any opponents, two opponents I think.

Third item, reprocessing, recycling and plutonium management. We do not need to wait for the outcome of these research programs to know that radioactive products requiring isolation for thousands of years must be minimized if future generations are not to inherit mines of plutonium and long-lived radioactive waste. In fact, plutonium will represent 95 percent of the radiotoxicity of the spent fuel after 10,000 years.

Reprocessing and recycling of fissile materials help to achieve this goal. Plutonium from spent fuel reprocessing may be recycled in pressurized water reactors as MOX fuel or in fast reactors, in

either a breeding or an incinerating mode. Recycling saves energy supplies and natural resources, which all told was important for us. In addition, reprocessing makes it possible to solidify the minor actinides and fission products, the only real waste, devoid of energy value, into forms suitable for final disposal.

To prevent separated plutonium from being stockpiled, the French utility EDF reprocesses its spent fuel only when it has a specific use for the separated plutonium. Therefore, how much fuel is reprocessed is not just a function of reprocessing plant capacity, but also of MOX fuel fabrication capacities and reactors licensed to use MOX fuel.

The MELOX plant at Marcoule, scheduled to start up in 1995, will have capacity of 120 tons of MOX fuel from the eight tons of plutonium that reprocessing plant La Hague can produce each year. One hundred and twenty tons of MOX fuel corresponds to nearly 20 reloads. Six reactors are loaded with MOX fuel at the present time. This number will gradually rise to around 20 by the end of the decade and possibly more later.

(Slide) Some figures which are given by the -- yes, by that chart, a reactor loaded with MOX fuel produces plutonium and consumes it at the same

time. Currently a reactor loaded with MOX fuel produces a total of 60 kilograms of plutonium per year, while a reactor loaded with conventional fuel produces 230 kilograms of plutonium per year. Research is underway to reduce the net plutonium production of reactor loaded with MOX fuel further or even to make it a negative value. The MOX fuels at the present time is -- the reactors with MOX fuels are 30 percent MOX fuels only.

Recycling in fast reactors, research is in progress to study the potential for incinerating plutonium in fast reactors. This is the subject of the CEA's CAPRA program in which several countries are participating, including Japan. Superphenix will restart in a few weeks for this purpose.

Depending on the results of this program, we could ultimately foresee a mixed reactor program that combines pressurized water reactor operating with conventional fuel or MOX fuel and fast reactors. This would allow us to stabilize our plutonium inventory, whether or not the plutonium is separated.

In conclusion, I would like to say that our use of plutonium in the nuclear power program is already a commercial reality that meets our needs in terms of natural resource conservation and

environmental protection and that does not raise proliferation concerns because it is properly safeguarded by international organizations such as the IAEA.

Plutonium is produced by reactor operations, not by reprocessing. Reprocessing is a relatively simple chemical operation that merely separates plutonium, but it requires impressive facilities to protect operating personnel from radiation and to protect the environment. Some power reactors, such as the Canadian Candu reactor, permit continuous discharge of low irradiated fuel capable of supplying weapons grade plutonium. These reactors are therefore intrinsically more proliferating than pressurized water reactors and the reprocessing plants that serve them.

Lastly, countries that have proliferated in recent years via the plutonium path have done so with materials from continuous discharge reactors or from research reactors. In no case have pressurized water reactors, fast breeder reactors or commercial reprocessing plants safeguarded by the IAEA been implicated.

In this regard, there is no need to tighten safeguards on nuclear facilities already

safeguarded by the IAEA, nor is it necessary to adopt international plutonium management measures. However, it is certainly essential to show greater openness and complete transparency and to explain how plutonium is used by the civilian nuclear industry and in what amounts. France is prepared to act so.

We will now show you a film, a movie, to illustrate my remarks. Then I will turn the floor over to Mr. Ricaud, Mr. Kaluzny, and Mr. Camarcat, who will explain the points I have raised in greater detail.

I thank you.

CHAIRMAN SELIN: Thank you.

(Video presentation.)

FEMALE NARRATOR: The beginning of the summer of 1994 coincides with the completion of the 58th French nuclear power station located at Civo in Western France. At present, 54 PWR nuclear units are being operated in France and four more units are currently under construction. In 1993, nuclear power accounted for 78 percent of the electricity produced by EDF, making France the number one user of this type of energy.

MALE NARRATOR: Three important organizations contribute to making the French nuclear

industry a coherent system: the CEA, with its research centers at Saclay, Fontiney (phonetic), Grenoble and Cadarache; COGEMA and its subsidiaries, with the Eurodif fuel enrichment plant, the fuel production plants at Omon (phonetic), Pierrelatte and Cadarache, and the reprocessing plant at La Hague; and finally ANDRA with its radioactive waste storage centers in La Manche and L'Aube departments.

FEMALE NARRATOR: Development and growth have always gone hand in hand with increased energy demands. However, the world's energy resources are very unevenly distributed between the various consumer countries. The life expectancy of the proven reserves varies considerably from one type of energy to the next. As a result, there are many different energy policies reflecting the diversity of the situations confronting individual countries.

Viewed in this context, France's situation is characterized by a distinct imbalance. The country owns less than 0.1 percent of the known energy reserves on the planet, whereas it has a level of consumption which represents almost three percent of the world total.

The geography of France certainly lends itself to hydropower production, but almost all the

worthwhile sites have already been equipped. France consequently decided, following the first oil crisis in 1973, to pursue an ambitious policy designed to limit energy dependency. This involved, on one hand, a far-reaching energy saving program and, on the other, the development of nuclear fueled electricity production.

Thanks to this strategy which has been diligently implemented, the energy independence of France has climbed from 22 percent in 1973 to almost 50 percent today.

MALE NARRATOR: In order to guarantee its independence in terms of energy requirements, France has over the last 30 years built up its own nuclear fuel cycle industry. In 1976. COGEMA was appointed to manage this industry. Today, the group is involved in all stages of the cycle, extraction, conversion, uranium enrichment, fuel production, reprocessing and recycling.

FEMALE NARRATOR: As far as the end of the cycle is concerned, both for energy-related reasons and in order to optimize ultimate waste management, France chose a closed cycle involving the reprocessing of spent fuel and recycling of valuable matter.

MALE NARRATOR: Up to now, over 15,000

tons of gas graphite fuel and 6,000 tons of light water fuel have been reprocessed by the Marcoule and La Hague facilities.

At present, COGEMA can handle 1600 tons of light water fuel per year at its La Hague facility. The UP2-800 and UP3 plants, each of which can process 800 tons per year, equivalent to the tonnage produced by 80 to 100 reactors, process spent fuel from France, elsewhere in Europe, Germany, Switzerland, Belgium and the Netherlands and Japan. These fully automated, remote controlled plants, UP3 was commissioned in 1990, followed in 1994 by UP2-800, belong to the new generation of reprocessing plants and represent the advent of industrial maturity for the end of the cycle.

FEMALE NARRATOR: The plants were designed to comply with extremely strict standards set by the French authorities with respect to safety, the dose exposure of personnel, environmental impact, and the volume and toxicity of the ultimate waste. In 1994, La Hague will reprocess 1300 tons of fuel and should reach its design capacity of 1600 tons per year by 1996. This gradual build-up to full capacity has been taking place since 1990 under excellent operating and safety conditions and the order book for the plant is

almost full for next ten years.

MALE NARRATOR: Spent nuclear fuel is transported to La Hague in special containers or casks. The casks are shipped from Japan and transported by rail from other areas of France and Europe. They pass through the Valonia (phonetic) rail terminal and are then taken to the plant on trucks. COGEMA has special lifting facilities at the Port of Chevour (phonetic) and at Valonia, which have so far handled a total of 15,000 tons of light water fuel.

The casks are either unloaded dry in the T0 workshop or underwater in the NPH workshop. The fuel is stored for several years underwater in one of the four pools on the site which have a total capacity of 14,000 tons. After this, the fuel is reprocessed.

FEMALE NARRATOR: Reprocessing involves taking the spent fuel and separating any recyclable matter containing energy, uranium, 96 percent, and plutonium, one percent, from unrecoverable fission products, three percent. The latter must be conditioned in the form of final residue prior to long-term storage.

MALE NARRATOR: All the reprocessing operations are part of a continuous process. The first stage involves shearing and dissolution. After

removal from the pool, the spent fuel is cut into sections three centimeters long and then immersed in a dissolver filled with nitric acid. Here the nuclear matter, uranium, plutonium and fission products, is transformed into a solution. The uranium and the plutonium are then separated from the fission products by a chemical process, purified and conditioned prior to recycling.

FEMALE NARRATOR: Nowadays the recovery rates for plutonium and uranium have reached fairly satisfactory levels, 99.88 percent, which helps to keep the plutonium toxicity of ultimate waste as low as possible. Only 0.1 percent of the plutonium ends up in the vitrified waste.

Concerning personnel dose exposures and the impact on the environment, the facilities are designed and operated in such a way as to keep both as low as reasonably achievable, or ALARA. Personnel dose exposure results for 1993 show an annual average per person per year of 0.43 millisevert, which is ten times lower than the standard currently applied to the general public and 100 times lower than the standard for people working in the industry.

MALE NARRATOR: The principles underlying the design of the plant, such as the choice of a

completely centralized control system or robot maintenance techniques which are remote-controlled from the workshops, go a long way to explaining these results.

FEMALE NARRATOR: An impact study of waste released into the sea shows that its effect has steadily declined, despite the fact that over the same period the plant has gradually been building up to full capacity.

MALE NARRATOR: The volume of reprocessed fuel rose from 250 tons in 1984 to almost 1,000 tons in 1993. At the same time, the alpha and beta gamma emitters, not including tritium, contained in the releases have been reduced by a factor of between five and ten. In order to monitor the impact of the releases on terrestrial and marine ecosystems as precisely as possible, COGEMA l'Aube collects and analyzes about 20,000 samples, grass, milk, sand, fish and so on, every year.

FEMALE NARRATOR: The results show that when detectable the impact on each species or element under analysis corresponds to a few percent of natural radioactivity. Under these conditions, the releases from La Hague have a negligible effect on the health of the local population, equivalent to about 1,000 of

the permissible annual limit for the general public.

Any industrial activity produces waste. The reprocessing and recycling of spent fuel produces two main types of waste: process waste, or in other words fuel components, fission products and the metallic substances in the fuel which cannot be reused; technological waste, or in other words waste produced during reprocessing itself, most of which is fairly inactive.

MALE NARRATOR: At La Hague, in the UP3, UP2-800 generation plant, all waste is conditioned on-line. Fission products are enclosed in a glass matrix. Hulls and end fittings are concreted. Solid technological waste, pumps, valves, gloves and used equipment, are also concreted. Effluent processing sludge is packed in bitumen.

FEMALE NARRATOR: In all cases, the residues are elaborated in the same way as any other industrial product, with technical specifications which must meet very precise requirements approved by the French safety authorities and their equivalent in Japan, Germany, Switzerland, Belgium and the Netherlands. Following processing at La Hague, the residues are stored for several years on-site before being returned to the owners, the power companies.

MALE NARRATOR: To begin with, the fission product solutions are calcinated in the vitrification facilities at La Hague. The resulting calcine is then mixed with glass frit and the mixture is heated to over 1,000 degrees in order to obtain homogeneous and chemically stable glass, capable of guaranteeing effective, long-term confinement of the radioactive matter. The glass is then poured into refractory steel containers which are subsequently stored in ventilated pits prior to reshipment.

Up to now, the vitrification facilities at La Hague have produced over 2700 glass containers and have conditioned all the fission products separated by UP3 and UP2-800.

At the end of 1994, the first cask containing 28 glass containers will be handed over to the owners of the residues, a group of Japanese power companies. The cask will return to Japan on one of the ships which regularly transport spent fuel between Europe and Japan.

The volume of waste produced by UP3 is already extremely low. Between now and the year 2000 further progress is expected. In 1995, the use of bitumen is to be discontinued and the introduction of new compaction and incineration technologies a few

years later should cut the volume of metallic and technological waste by a factor of five.

At present, the total volume of high and medium activity waste produced during reprocessing is lower than the estimates made by the Swedes on the basis of direct storage of conditioned spent fuel. Looking ahead to the end of the century, this amount should have fallen to less than 0.5 cubic meters per ton or, in other words, one-third of the volume of conditioned, unprocessed fuel.

FEMALE NARRATOR: EDF activity as a nuclear power producer is part of a long-term strategic perspective, especially with regard to the management of plutonium. Part of the plutonium produced in nuclear fuel during its presence in the reactor undergoes a fission reaction and thus accounts for between 30 and 40 percent of the electricity produced by nuclear power stations. The remaining plutonium, which is recovered during reprocessing, can in turn be used. It has considerable potential as an energy source. During the first MOX recycling process, a gram of plutonium can produce as much electricity as a ton of oil. This explains why the French power company plans to recycle its plutonium in the form of MOX fuel for use in its 900 megawatt PWRs.

MALE NARRATOR: Seven PWRs have already been loaded with this fuel and EDF plants do MOX 22 to 28 of its 900 megawatt reactors between now and the end of this century. MOX fuel performance is gradually approaching the levels achieved by enriched uranium fuel. High burn-up, 45,000 megawatt days per ton of uranium. Load and grid following, quarter core reload management.

FEMALE NARRATOR: A MOX reactor has a distinct advantage over an enriched uranium reactor. It produces very little or no plutonium at all, thus contributing to stabilizing or even reducing the plutonium inventory when burn-up increases. Then, as more and more nuclear power plants are MOXed, so less and less plutonium will be produced.

MALE NARRATOR: The techniques used to recycle plutonium are currently the subject of significant research and development programs in France. Their aim is to improve the efficiency of existing reactors and prepare the way for a new generation of reactors. Within this framework, the CEA is pursuing two lines of development, increase the proportion of plutonium in light water reactor fuel and burn-up in MOX cores, develop new types of reactors, in particular fast breeder reactors which

are especially adapted to consume plutonium fuel. It is also studying the use of these new types of reactors for transmuting actinides and fission products separated during reprocessing.

FEMALE NARRATOR: This research work benefits in particular from the capacities of the Superphenix fast breeder reactor which, just recently on July 12th, 1994, was newly authorized to start-up operations.

MALE NARRATOR: Two manufacturing plants currently supply French and European reactors with MOX fuel, the Dessel plant in Belgium, which belongs to Dessel plant in Belgium, which belongs to Belgo Nucleaire, and the Cadarache plant in France, which is run by COGEMA.

FEMALE NARRATOR: From 1995 onwards, capacity will increase with the industrial start-up of the MELOX factory currently nearing completion at Marcoule in Southeast France. MELOX, with a production capacity of 120 tons per year, is the first fully automated plutonium fuel manufacturing unit.

MALE NARRATOR: Plutonium arrives at MELOX in specially designed transport casks. Inside each cask, three successive barriers of packing guarantee plutonium confinement. Without leaving its cask, the

plutonium is stored in a safe under the constant surveillance of the factory operator. As is the case with all the other reprocessing and recycling activities in France, MELOX operations are placed under the control of the appropriate national and international authorities and, in particular, the IAEA and EURATOM.

FEMALE NARRATOR: The MELOX production process uses proven and qualified techniques. As with the case at La Hague, the search for high performance of MELOX and the determination to provide the best possible working conditions for personnel, lead to the choice of a fully automated control system. A real time computer system tracks products, monitors their compliance with specifications, and manages the nuclear materials passing through the facility.

MALE NARRATOR: To begin with, the plutonium and uranium oxide powders are measured and mixed in a ball crusher to obtain a homogeneous mixture. The powder is then made into pellets. The pellets are then centered in high temperature continuous process furnaces prior to being ground and sorted by an expert system using image recognition technology. Product quality is monitored on a permanent basis by laboratory analysis of samples

taken at various stages of the production process.

Once they have been accepted, the pellets are packed into fuel rods which are assembled in a special square sided structure to complete the fuel assembly. At MELOX, the assembly technologies are exactly the same as those used in uranium fuel manufacturing plants. MELOX will output approximately 100,000 pellets per day or, in other words, 350 rods, corresponding to approximately one fuel assembly.

FEMALE NARRATOR: The design of the MELOX plant and its subsequent operation are subject to extremely strict safety requirements, especially with respect to product confinement, fire protection, earthquake resistance, protection of personnel, as well as management of rejects and waste.

MALE NARRATOR: The average radiological exposure for operating personnel at MELOX will be less than one-tenth of the maximum permissible annual dose and liquid and gas releases will be negligible. In addition, all the waste produced by the MELOX plant will be sorted, recycled and conditioned on-line. Production rejects will be completely recycled either by the MELOX process itself or by dissolution at La Hague. Wherever possible, waste will be incinerated, ash will be lixiviated in order to extract any

plutonium and the final residues will be vitrified. Waste which cannot be incinerated will be decontaminated and conditioned in concrete prior to final storage.

FEMALE NARRATOR: In France, radioactive waste is managed by ANDRA, Agency for Radioactive Waste Management. Management concepts vary, depending on whether they concern long or short-lived waste.

MALE NARRATOR: Most short-lived waste is produced by nuclear power plants, but hospitals, industry and certainly research centers are also responsible for small amounts. Waste is compacted and packaged on-site. The waste inside the packages is coated. The packages are checked.

FEMALE NARRATOR: ANDRA has drawn up specifications relating to the nature and radioactivity of waste as well as how it should be packed. For instance, all waste should be solidified inside the packages. The size and shape of packages have also been standardized. Radioactive waste has become a stable, reliable industrial product.

ANDRA carries out regular audits of waste producers, checking the quality of waste packaging.

MALE NARRATOR: Once it has been prepared, each package is numbered. It can thus be monitored by

a computer until final storage. Waste packages travel from the production site to the storage center by road and rail. As is the case for all nuclear materials, their transport is subject to national regulations based on international recommendations. Their safety depends to a large extent on the quality of the packaging and the precision of transport procedures.

FEMALE NARRATOR: Today, all short-lived waste produced in France is stored at the Aube Center. It is taken over from the Manche Center where the operating phase has just ended. Five hundred twenty five thousand cubic meters of waste are now stored at the Manche Center. The Aube Center has a capacity of one million cubic meters.

MALE NARRATOR: On arrival at the center, the load is checked for conformity with a consignment note. Thanks to the experience gained at the Manche storage center, ANDRA has improved the storage conditions for short-lived waste. Waste is placed in concrete enclosures protected from the rain by removable roofs until they are enclosed. A laser beam reads the bar code label on each package. All the data are centralized, providing accurate information as to the location of each package within the structure. A layer of concrete is poured over each

layer of packages. Once the enclosure is full it is enclosed by a reinforced concrete slab.

The storage cells at the Aube Center will subsequently be covered in the same way as at the Manche Center, by a final protective layer comprising a bituminous membrane and several layers of clay and topsoil which will then be grassed over. This covering protects the waste packages from the weather.

The tightness of the storage systems at the Manche and Aube Centers can be checked from a series of inspection galleries running underneath the structures.

FEMALE NARRATOR: The Aube site will enter its monitoring phase in about the year 2040. This phase will last 300 years, until the radioactivity in the waste has declined to the same level as natural radioactivity.

MALE NARRATOR: The site has created about 200 jobs, 80 percent of which are for local people. It contributes to the local economy and has been accepted by the population, who enjoy access to all the information concerning environmental monitoring and the running of the center.

The technology used at the Aube Center has earned international recognition and has been exported

in particular to El Cabril Center in Spain and to the USA.

FEMALE NARRATOR: Long-lived radioactive waste, and in particular the glass canisters produced in the reprocessing plants, or CEA centers, is stored temporarily on the production site. During the '70s and '80s, it was thought that this type of waste could be buried deep underground. This type of solution was considered by a number of countries at that time. However, when steady work turned to specific sites, the local population reacted unfavorably to the idea of long-term storage.

After a two year moratorium, the French Parliament voted the law dated December 30th, 1991. It sets out lines of research for the long-term management of radioactive waste. The findings of this research work will be examined by Parliament in the year 2006, at which point the appropriate solution will be chosen.

MALE NARRATOR: Amongst the solutions currently under study, ANDRA is looking at storage in deep geological formations. In order to check the validity of this solution, it has been decided that ANDRA should build underground laboratories.

FEMALE NARRATOR: The government appointed

a member of parliament to act as Mediator and look for local authorities interested in accommodating an underground laboratory.

MALE NARRATOR: Following this stage, ANDRA has been authorized to proceed with preliminary work on four sites, one in a granite rock formation, the three others in clay. The siting of the laboratories depends on technical safety considerations, but also requires the approval of local authorities.

FEMALE NARRATOR: ANDRA has carried out information campaigns and its own engineers present the projected laboratories to the general public and explain the preliminary work involved. These campaigns are currently underway in four French departments, which volunteered to accommodate a laboratory.

MALE NARRATOR: The projects are illustrated by scale models. On the surface, the laboratories look very much like small industrial estates. The underground parts of each laboratory will comprise several experimental halls linked by a system of galleries. Research will be carried out on the digging and the supporting of these galleries. Hydraulic, thermal and mechanical studies will also be

carried out in order to confirm that underground storage is effective and safe for the very long-term confinement of radioactive waste.

Experiments are being carried out in association with foreign laboratories. They will subsequently be carried out in underground laboratories in France. They concern excavation techniques as well as rock strength, permeability and confinement capacity.

FEMALE NARRATOR: The results of this research work will be taken into account by the French Parliament when it takes its decision in the year 2006. Thanks to a flexible schedule and the government's political commitments, the debate on the management of long-lived radioactive waste now enjoys some much needed serenity.

(Video presentation concluded.)

CHAIRMAN SELIN: That was an excellent film. We are particularly impressed that it includes a fact that happened only last week.

MR. MANDIL: That's right. May I give the floor to --

CHAIRMAN SELIN: Please.

MR. MANDIL: Jean-Louis Ricaud from COGEMA now.

MR. RICAUD: I am Jean-Louis Ricaud, COGEMA Senior Vice President for Reprocessing and Engineering Divisions, and it's a pleasure for us today to have opportunity to share information with you.

As you know, COGEMA is a complete fuel cycle company which include front-end activities, like mining, uranium enrichment, fuel fabrication in Framatome and which is also involved in back-end activities like reprocessing and plutonium recycling.

As was shown in the movie, COGEMA operates two reprocessing plants in La Hague and these plants have reprocessed from the beginning to now more than 6,000 metric tons of light-water fuels. In '94, we'll process more than 1,000 square tons of light-water spent fuel for our European and Japanese and French customers. There are more than 9,000 tons of spent fuel which are now safely stored in our ponds waiting for reprocessing. So, we have the feeling that these results demonstrate safe, reliable and environmentally sound operations.

Nowadays, recycling of reprocessed uranium in standard fuels is well demonstrated. Recycling of plutonium as MOX has been demonstrated in light-water reactors since the early '60s. In '93, there are more

than 50 tons of MOX fabrication capacity which is in the operation and it will rise progressively to 300 tons by the end of century. So, new plants, like MELOX and BNFL plant in Great Britain. MELOX, the new MOX fabrication plant in Marcoule, the South of France, will start up by the end of this year and will begin with the industrial operation in '95, next year.

Today, seven light water reactors, the last one is Blayais, which was just loaded with MOX fuel at the end of last month and which will start up soon. Seven such units now are loaded with MOX fuels. I think it's possible to say that the operating experience is totally satisfactory. By 2000, when all the investment and all the licensing will be done, will be completed, sorry, MOX will be loaded in at least 16 and I'm quite sure 20 to 28 units in France. So, it means that now plutonium recycling is an industrial reality.

I would like to focus on two specific topics which are economics and non-proliferation topics, which are, of course, very important ones in these fields because we know, of course, that some, especially here, criticize reprocessing and recycling on economic grounds. Certainly if you look to this cost of reprocessing and recycling and compare it only

to this price for uranium enrichment, you may reach that conclusion. However, in countries which don't have the vast energy resources you enjoy here in the U.S., reprocessing and recycling make eminent sense.

Just have a look at the most recent OECD report which tried to compare the cost of recycling route and once-through cycle and it demonstrate that the costs don't differ very much. This chart in front of you show you that with a discount rate of -- the cost difference between the two routes is about .06 Francs spent a kilowatt hour. Of course, if you tried to compare these two routes, you are to take into account the fact that cost of reprocessing and recycling are quite well known, while cost of other routes are estimated. But through reprocessing and recycling, waste streams are segregated and conditioned in a manner which would permit optimization of disposal methods. Finally, that the evolution of cost in the future in the front end is forecast to be clear. I mean the cost might increase and the comparison will change.

We don't think that those who view the question differently must adopt our conclusions. However, we have the feeling that our choice has been made on the basis of a careful analysis as a part of

a long-term, coherent energy strategy.

CHAIRMAN SELIN: I would like to stop you for a minute. First, I'd like to apologize for changing your name. I rather like Jean-Claude as a name, but if you want to still be Jean-Louis, that's all right. But let me ask you a question about the reprocessing.

There are actually two stages in the reprocessing, one of which separates out the uranium and some of the plutonium from the rest of the plutonium and the wastes, and the second one which further refines the waste to try to separate almost all the plutonium from the waste. The economic value of the plutonium is not large. You're only talking about one percent of the entire recycled fuel to be plutonium. If you did not have the second stage, if you did not try to purify the wastes of plutonium, it is true there would be some plutonium in the waste, but it would be in a very highly toxic form where the risk of somebody converting this into weapon material is rather low.

I should also tell you we are not trying to figure out what the French should do, but we are asked by the Chinese, by the Slovaks, by the Czechs what they should do about waste. I'm trying to

understand what the benefit is of that second stage of plutonium separation because it does contribute considerably to the cost. I wonder if you could address that question.

MR. RICAUD: You're absolutely right. In fact, that's true that the new reprocessing plants, like UP3 and UP2-800, have been designed as to reduce as low as possible plutonium quantities in the waste. You saw in the movie a figure which showed that we extract close by 99.9 percent of plutonium and that in the waste it will remain 0.1 percent of plutonium. We made calculation as to try to answer the question you raise. It's our feeling that if we assume that we try to reach only 99 percent and not 99.9, we shall decrease reprocessing and recycling route cost for about 30 persons. So, it means that coming from 99 to 99.9 percent of plutonium in spent fuel increased the cost of the route of 30 persons.

CHAIRMAN SELIN: What is the benefit of doing this last stage? What is the reason behind doing it?

MR. RICAUD: The reason for COGEMA is that its customer asked for and why they ask for, because in France, for example, if the authorities ask for, you have to know. For example, for a MELOX plant

which will manage, roughly speaking, ten tons of plutonium per year, we are asked not to have more than 300 grams of plutonium in the waste per year. So, we are asked by our clients to do that. So, that's, in fact, I think linked to the general approach in these fields, which is our approach in France and in some countries where we say we have to decrease as low as reasonably achievable.

CHAIRMAN SELIN: But the toxicity of the waste -- is the toxicity of the waste changed considerably by taking out that last one-tenth, one percent of plutonium? It's not an economic question obviously. Is it a question of toxicity or is it a question of safety or is it a question -- I don't quite understand what the benefit is. Is it toxicity?

MR. RICAUD: My feeling is that it might be a critical benefit. I mean it will demonstrate that the waste we'll have to bury will be as low contaminated as reasonably achievable. And to say, "Okay, we may prove that the waste, the glass canisters, we include as low quantity of long-lived emitters as we were able to do." I think we say that it was quite important agreement to use --

CHAIRMAN SELIN: That's in France. But if we're talking about a third country and they ask,

"Well, what if we don't take out that last one percent plutonium?" would that have a significant effect on the toxicity of the remaining waste?

MR. KALUZNY: Perhaps a complimentary answer. I think as Ricaud said, in France, of course, they are very concerned with this type of waste. Long-lived radioisotope is a concern for the public. We have often the question which is quite simple, have you done the maximum to reduce the toxicity of the waste? So, after you have the industrial process, of course we would like to have even less plutonium in the waste. Of course we would like to have even less neptunium, americium or curium which are also very radiotoxic radionuclide.

So, there is a general demand in France. I think that in other countries we could have such a problem when you try to implement the final disposal. This question will raise up. But at a certain stage we must have an assessment between what is possible to do from an industrial point of view and, of course, the environmental point of view.

CHAIRMAN SELIN: Thank you very much. But the question was a technical question, is this three-quarters of the toxicity in the remaining fuel, is it five percent, ten percent? There are many other long-

lived radionuclides in the fuel, in the waste as well, but I think you've answered the question. Thank you for that.

MR. RICAUD: Now I would like to address in a few words non-proliferation topics.

Of course, nuclear proliferation is a serious and complex matter which is first has to be addressed by government representatives. But I think we have to briefly comment our feeling about these topics.

The NP Treaty, which was signed in 1970, established a framework for civilian nuclear trade among signatories, each of whom agrees to IAEA safeguards. The NPT guarantees member nations the right to develop peaceful use of nuclear energy and to engage in trade as long as safeguards are respected. COGEMA, as a member of the commercial nuclear industry in a country who signed the NPT, of course supports extension of the whole of NPT as peaceful of the world.

So, COGEMA is dedicated to prevent proliferation, as is our government. We adhere stringently to all IAEA and EURATOM safeguards. Safeguards are doing what they are intended to do, prevent diversion of nuclear material from civilian

safeguarded facilities. Physical security and safeguards are an integral and vital part of COGEMA's facilities and transportation system.

There has never been a diversion of plutonium from safeguarded facilities. Rather, every instance of known or suspected proliferation involved clandestine production facilities. I think it's necessary to say that contrary to the implication of some reports, reactor-grade plutonium is not realistically a potential weapons material. The chart, try to remember what is the difference between weapons-grade material and reactor-grade material. Weapon-grade in red and reactor-grade in green. This chart shows that more the burn-up of the fuel is high, less the plutonium is close to weapon-grade plutonium and more it becomes reactor-grade plutonium.

We appreciate that in a recent publication, a DOE press release citing 32 year-old study by the U.S. defense establishment, confirmed that the fuel which was used to organize this test came from a graphite-moderated reactor of the U.K. which was subjected to extremely low burn-up. That means that no LWR fuel normally used have so low burn-up. So, are able to deliver plutonium which will support such a test. So, it means that, in fact, that

the plutonium used in 1962 was not, not, be classified as civil reactor plutonium. This fuel, in fact, we have the feeling it was closer in nature to fuel used by the defense establishment than to any commercial LWR fuel reprocess.

Finally, I would like to say that we treat reactor-grade plutonium in its separated form as only an intermediate step in an entire process whose objective is precisely to use and consume plutonium. In terms of non-proliferation, recycling therefore offers a distinct advantage. The plutonium which is generated by nuclear power plants is burned in those same plants, thereby restricting the growth of the world's plutonium inventories. The chart shows you that the more you have MOX units in a country, the less you generate plutonium for the same total quantity of electricity generated during the year.

So, finally, I would like to point out the fact that reprocessing and recycling industry development, in fact, a lot of techniques have been developed which may be applied here and there. You have in mind that, for example, the vitrification technology which was developed in France has been licensed in Great Britain for BNFL use. Spent fuel handling and unloading system which have been

developed for reprocessing plants are used not only for the Japanese reprocessing facilities but also in Sweden for interim storage, known as CLAB, which is equipped with equipments which have been first used in reprocessing plants. We are currently trying to apply some of our expertise in U.S. study of handling system, as you know.

Our transportation programs provide a sound experience base for any spent fuel management program. It was said that 15,000 tons of light water spent fuel have been safely transported from reactors in Europe and Japan to La Hague. More than 4,000 cask shipments by rail and sea have been performed in completely safe and secure conditions. So, I have a feeling that these examples simply illustrate the capabilities of technology developed in reprocessing programs to other situations and highlight the continuing importance of international cooperation in addressing issues that face our nuclear industry in every country.

To conclude, I would just like to say that we enjoy today to have the opportunity to show these realization and to discuss these topics in depth. As you can see, our viewpoint, as well as we think the viewpoint of our government, is that nuclear recycling

is responsible and maximizes use of energy material. Well, of course, by explaining our position, we hope in fact that those who do not share our views will appreciate and respect what we are doing and why we are pursuing our strategy so decisively.

Thank you.

CHAIRMAN SELIN: One thing that we need to do in order to appreciate your views is to understand them a little bit better. So, I could ask many questions, but I will content myself with two.

The first, when you talk about the economics, these are complicated calculations because they have to do with capital costs, costs later on, the value of what comes -- the results of the reprocessing process. But as I understand it, the reprocessing price is approximately $1,000.00 U.S. dollars per kilogram today. Is that about right?

MR. RICAUD: That's right.

CHAIRMAN SELIN: If you were talking to a third country, a country that might buy technology from France or from another one of the reprocessing people and they were going to set up a reprocessing facility, would that be a reasonable estimate of the cost to set up a new facility?

MR. RICAUD: I think that in China it may

be a lower cost and in Japan it might be higher. It depends, of course, on the economic situation of each country. So, it's quite difficult to compare such cost from a country to the other one --

CHAIRMAN SELIN: Well, that's true.

MR. RICAUD: -- because the economic situation condition are so different.

CHAIRMAN SELIN: But there were really three parts. The first, is that pretty much the process that you would suggest the Chinese or the Japanese adopt? If you were doing this for, say, China, would you modify the process significantly in a way that would change the costs significantly?

MR. RICAUD: Well, I think that the Japanese project is quite similar with our project and in China there are no existing industrial project as I know. But my feeling is that the key parts of the process will be the same.

CHAIRMAN SELIN: The second part of this is we've already discussed this last stage of separating the last small amount of plutonium from the waste. Is there any other part of the process that you could consider to be optional that is not intrinsic in the process, or is that basically the largest decision that could be made as far as the

investment cost?

MR. RICAUD: In fact, the key part of our processing plant is, in fact, the shearing facility and chemical extraction facilities. So, and that's only one step of the total amount of invest of reprocessing plant. Around that, you may have larger or small ponds to store fuel before reprocessing and you may package all the waste in different forms. For example, in our process we vitrify all the fission products. It's one way to manage. There might be others less or more expensive.

So, I think that we have to distinguish when you examine these topics the key part of the process itself, separating uranium products, and I will call them the finishing units and the process you apply to each flow as to recycled materials or as to package the waste in the suitable form, depending upon the place where you have to dispose them.

CHAIRMAN SELIN: And the third question, going back to the key part, the separation part, is there much effect on volume? If it were 400 tons or if it were 1200 tons instead of 800 tons, would that change the unit costs?

MR. RICAUD: What is true is the fact that the best size for a reprocessing plant is between 800

to 1,000 tons. The invest cost for such a plant whatever would be the capacity between, I would say, 100 and 1,000 tons will be quite the same. In fact, it's true that in La Hague we are quite lucky to have the opportunity to have two such plants on the same site because there are a lot of common facilities which are shared between the two plants. For example, the effluent treatment facility. For example, technological waste packaging and so on. So, the air pressure destabilization system. So, all these common facilities costs are shared between the two plants.

So, I think that in La Hague we are about to reach quite a competitive price for reprocessing and recycling $1,000.00 per kilogram of spent fuel. That's due to this good size of these two plants and common units shared between them.

COMMISSIONER de PLANQUE: I have a technical question. Once you're into the MOX fuel design, is there any limit to the number of times you can reprocess either from a technical or an economic point of view?

MR. RICAUD: We have proved in La Hague that it's possible to reprocess MOX fuels. In '92, in UP2 reprocessing plant, we have reprocessed five tons of MOX fuels. So, now, I think it's possible to say

that reprocessing of MOX fuel is qualified.

COMMISSIONER de PLANQUE: Technically.

MR. RICAUD: Technically. And the price for reprocessing of MOX fuel is quite the same as for uranium fuel, $1,000.00 per kilogram, roughly speaking. But of course it is true that when you recycle plutonium in light water fuels, it becomes, I would say, more and more civilian plutonium. I mean that the quantity of fissile isotope decrease. After two or three such recycling steps, the quantity of non-fissile material inside plutonium become too high to unable recycling of this plutonium in light water fuels. But it remains possible at this time to recycle such plutonium in brittle fuels, for example, and that's one of the use of Superphenix which will be starting in the near future.

COMMISSIONER ROGERS: Just a question on your transportation casks. Are the regulatory requirements that those transportation casks have to satisfy similar to the ones that are imposed here in the United States? Do you know that, in terms of design basis accident, for an example, in which they'd have to withstand. Are they comparable or are they significantly different?

MR. RICAUD: All our casks and

transportation system will fulfill all the international recommendations from IAEA, namely speaking. So, in these fields, our casks are able to travel everywhere in the world. For example, casks are used from Japan to Great Britain to France. The same type of casks are used in Sweden to transport spent fuel from the nuclear power plants to central storage, named CLAB. I have in mind the fact that such casks have been licensed in the past for special use in the U.S. themselves. So, it means that, in fact, they comply with all the regulations which are enforced all over the world.

COMMISSIONER ROGERS: Thank you.

MR. KALUZNY: Thank you very much. I'm Yves Kaluzny, Director of ANDRA. As you know, ANDRA is a public agency in France in charge of radioactive waste management.

So, the film has showed you the two main aspects of radioactive waste management. The first is the industrial aspect such as disposal and the second one is research aspect. That is the deep geology core disposal research program. I would like to focus my speech about the second aspect and to explain how we deal with the Radioactive Waste Act.

(Slide) First slide, please.

So, as you know, this act has one main issue for me. That is open widely the field of research. So, we have three ways. ANDRA is responsible for the second one, that is in-situ studies in underground laboratories. Of course, to implement this way of research, we have to know about the two other ways. That is partitioning and transmutation and long-term packing and storage. Why? Because when we have to think about the disposal design, we need to have the results of the other way. What kind of waste we have to put in the disposal? So, it is necessary to know the characteristic of the waste and the evolution we can have because when we are designing our disposal, it's not for today but for the long-term.

The second point is, of course, when you look at partitioning and transmutation, what type of radionuclide to separate and transmutate. That it is very important to have with the progress of our safety analysis of the geological disposal to know what are the main radionuclides to concern. For instance, is it important to separate the actinide like neptunium, curium, americium because of their chemical property in underground, or is it important to separate what we call the long-lived fission products? So, all the way

of research are, in fact, interconnected as to know the overall of this way of research.

(Slide) Second slide, please. Second chart, please.

So, the second issue of this act is to transform ANDRA as an independent public agency in charge of managing radioactive waste and in charge of preparation of the future. That is designing and building future repositories. The first mission of ANDRA is national inventory. This is inventory of all the radioactive waste disposed in France. We have published for the first time last year this inventory and each year we publish a new inventory. For us it is very important because, as you know, radioactivity is not only used in the fuel cycle industry, so it is very easy to know about the fuel cycle industry, but also in hospital and other part of industry. The way to have this inventory is something to organize the memory about radioactive waste, the nature, the quantities and their locations. So, in this inventory we have also the military radioactive waste.

(Slide) Next figure, please. Next chart.

Just a few words about ANDRA. ANDRA is a very small agency dealing with the responsibility. We have about 450 employees and a budget, this year

budget about one billion francs. Mainly in the research, such as deep geological program and the other part is the industrial part such as Centre de l'Aube operation and achieving Centre de la Manche covering.

I would like just to say that with so few people ANDRA is not performing its rituals by itself, but have some subcontractors like Commissariat a l'Energie Atomique for the radioactive part, like universities in France and, of course, other institutions dealing with geological matters.

(Slide) Next chart.

What is the time table? The law said to us that in 2006 we need a specific evaluation of the three research directions and so to propose the final decisions. So, to be able to do such a thing at this date, we need several steps. First, Bataille's mission. Bataille's mission was very successful because he raised four volunteer departments. One of the major things about the process in France is that we have asked for volunteer departments. There was not only a technical choice based on geological characteristic, but also we try to have a political consensus, not only on the national level but also at local level.

I think that Bataille's mission was successful for two reasons. First, the Radioactive Waste Act set the institutional control to control ANDRA activities, and also there was some financial incentive to accept a laboratory. For the first stage, which is preliminary site study, each community will have 5 million francs per year. Then when we will be at the laboratory stage, that will be about 60 million francs per year. So, it's very important for the local community to have this opportunity to perform some economical development. Of course, a laboratory is also a very huge investment. This is about 1.5 billion francs, each laboratory.

So, after Bataille's mission, today we are on the site to perform some preliminary work and to prepare the public inquiry and hearings. Of course in this process we need to have the formal approval of each local communities to be authorized to implement, to set up the laboratories.

CHAIRMAN SELIN: Could I stop you for a minute, Mr. Kaluzny?

MR. KALUZNY: Please.

CHAIRMAN SELIN: The three laboratories are to be built.

MR. KALUZNY: The basic figure is two

laboratories, but the law didn't say anything about the number of laboratories. That is more than one and I think that will be less than four.

CHAIRMAN SELIN: Is part of the evaluation to have waste forms in the laboratories to actually put some waste in these underground laboratories and measure the effects?

MR. KALUZNY: No. We don't plan to have radioactive waste in the laboratories. We perform only research. So, of course we could use some radioactive sources, but we have the obligation to put it out of the laboratory after the test. So, in this part, the laboratory is not a nuclear facility, it is only a research facility.

CHAIRMAN SELIN: I see.

COMMISSIONER ROGERS: Excuse me, on that point, is there a commitment at the very beginning that the laboratory will never ever be a site for high-level waste disposal?

MR. KALUZNY: No. Of course this research program is not only generic program but it is site-specific. So, we are very clear on this point. The laboratory can be transformed in a repository. But do to that, we need the evaluation. We need to have another act. So, another parliamentary discussion

about this program.

COMMISSIONER ROGERS: But that is not excluded?

MR. KALUZNY: No.

COMMISSIONER ROGERS: In fact, it's contemplated that eventually one would be a site. Is that it?

CHAIRMAN SELIN: I think we should have Mr. Bataille come brief us in the future. That's really quite an extraordinary process that you have gone through, including the public in the political life, both in your low-level and in your high-level waste experimental programs.

Please.

MR. KALUZNY: (Slide) Okay. Next chart, please. Next chart. Okay.

Just to show the location of the area, we have the Vienne Department in the west part of France. This is a granite formation. This is the only granite formation we have for this program. We have on the east part of France Department of Gard, Haute-Marn and Meuse, which are clay formations. So, this year we are performing some geophysic works on each site and some core bore hole. Our target is to confirm the potentiality of this area and then to be able to say

to the government at the end of this year, "We would like to implement the laboratory in such and such area." So, the government has to decide to authorize ANDRA to prepare the applications and then the construction of the laboratory.

Of course, the overall assessment is not for the end of this year, but at the end of the process, in 2006.

(Slide) Next chart, please.

To come back to what we call the openness, that is all the institutional controls related with the research program implementations. We have to perform some annual progress reports and review by a national board. This national board is not a governmental board, but its member was designated by both the Parliament and the government. This is independent. ANDRA has, of course, to report to the board and the board has to be report to the Parliament. So, the Parliament is still engaged in all the process. So, for us it is very important to be sure that we will have a good political involvement in all the process during such a long period of time.

What could be the role of this national board? The board has not only to look at the ANDRA works, but also the works performed in the two other

area of research. To assume that resources, financial resources are enough for each field of research and also to assess the priority of research. For us, this is a scientific guarantee and also a political guarantee because of the intervention of the Parliament.

The other point is a discussion with the communities. The first step was Bataille missions, of course. We have also some informal discussion with all the political responsible in the communities, but we have some formal instrument. That is to set up local information committees. What is a local information committee? This is a committee with some elected people, associations, trade unions and including some environmentalist associations. They have the opportunity to discuss about the project. This committee has a budget of one million francs per year to be able to appoint experts by instance to review ANDRA activities and sites. So, this is a very strong guarantee for the local community.

Then, concerning the final governmental decisions in 2006, there will be a general review and the government has to decide to propose a new radioactive waste act to decide other solutions. Of course, at this stage ANDRA will propose some designs

for disposal and so this will be an opportunity to have a parliamentary debate and to see at what condition a laboratory could be transformed in repository, so that is another strong guarantee for us.

CHAIRMAN SELIN: Assuming that the schedule is met, what date would you expect the repository to be available?

MR. KALUZNY: 2020 about.

COMMISSIONER de PLANQUE: Could you go back just a moment to the Board? You may have said it and I missed it, but how many people are on the Board and what types of people are on the Board?

MR. KALUZNY: (Slide) Please may I have the next chart? I think I have a chart.

COMMISSIONER de PLANQUE: We didn't plan that.

MR. KALUZNY: (Slide) Next one. The Board has about 12 people, six named by the Parliament, and including two international experts, one coming from OECD, that is Mr. Olivier in charge of the fuel cycle, and another coming from Switzerland that is Mr. Romanche (phonetic), former Chairman of Negal (phonetic), six experts named by the government, four proposed by the academicians, and two proposed by

the High Council of Information and Nuclear Safety. This Council has to give advice to the minister in charge of industry and also the minister in charge of the environment and all affiliated with nuclear energy.

COMMISSIONER de PLANQUE: Thank you.

MR. KALUZNY: Okay. So, to be very brief on the conclusions, I'd like to say that the process I've tried to describe to you is certainly a possible process, but not a unique solution. Each country has to think what could be a solution to try to deal with this huge problem which is radioactive waste management, and in this process we try to avoid only scientific and technical approach but we try to include a way, a political approach to which a minimum consensus on the main options we propose.

Thank you very much.

CHAIRMAN SELIN: Did you want to ask a question?

COMMISSIONER ROGERS: Yes, just one question. Several years ago you identified something like four possible sites and then found it necessary to postpone that process. Were those different sites from the four that you have now or were there some combination of those and these?

MR. KALUZNY: They are different.

COMMISSIONER ROGERS: They are.

MR. KALUZNY: Of course, during his mission Mr. Bataille tried to ask to the previous site, is their will voluntary? The answer was no. And that is very interesting because when you are political men who have taken some very strong positions it is very difficult to come back, and so these are new sites. And I would just like to say that Vienne, the site in the Vienne Department, is very close to the previous site which was in the Deux-Sevres Department and Menenwel (phonetic) Department.

And one interesting thing I have on the field today, that we have very low -- very few people against the laboratory which coming from the previous department, so I could say today that the process we engage is not so bad because we have a local consensus and a national consensus until now.

COMMISSIONER ROGERS: Thank you.

CHAIRMAN SELIN: That's very impressive.

COMMISSIONER ROGERS: Yes. It sounds very good.

CHAIRMAN SELIN: It's very good.

Before we go on to Mr. Camarcat, what is interesting is that those few countries, France,

Sweden, for instance, that have been successful so far in finding sites for their waste have had a very open process and have spent a lot of time and effort involving people. I've also noticed that all your sites are in places that have very good restaurants. I'm sure that's just a coincidence.

Mr. Camarcat?

MR. CAMARCAT: Thank you. My name is Noel Camarcat and I'm a Director for the Nuclear Fuel Cycle Division at France CEA.

(Slide) Can I have viewgraph number 1, please?

(Slide) Next one, please.

Now, as we've heard previously this morning, research for the back end of the nuclear fuel cycle is organized to answer the three items of the 1991 law, and so I will not go any further in the three research lines.

(Slide) And I will go to the next viewgraph, please, which is the petitioning and transmutation, what we call in French the SPIN, S-P-I-N Program. Now, it is organized in two research lines. The first one, we call it PURETEX, which has for objective the reduction of reprocessing waste, and we've seen it in the film. This is done closely, in

close effort with COGEMA, with the target for 1995 of .9 cubic meter processed of uranium and it has to decrease by nearly a factor of two by year 2000.

In research we make increased use of glasses and glasses have to be designed for a new kind of waste, the ones which were before in bitumen, and the research also has to improve the processes which will be used in plants UP2-800.

The second line of research of the SPIN Program is the ACTINEX, which we call partitioning of actinides and long-lived fission products. Two sublines of research, one, and this is going further than our previous discussion this morning, is to extract actinides with new solvents. One line is to make coextraction of americium, curium, and some fission product lanthanides with the new solvents. Experiments are being performed at lab scale in 1995.

The next step is the separation of americium and curium from the lanthanides, and then you go to actinide oxides which are mixed homogeneously and burned in a reactor. Obviously this line, it is not written on the viewgraph, goes also with the transformation of neptunium and the transformation of neptunium into oxide for burning, since neptunium has a very long half-life.

The second main research line is the extraction of long-lived fission products, but with special molecules which we call long cyclic macromolecules, and have listed a few scientific items of these specific atoms to be used.

(Slide) May I have next slide, please?

Now once you have a separation program or petitioning program you go to the transmutation part of the program and this work is performed in the Nuclear Reactor Division in which cores have been optimized for transmutation, that is PWR cores and breeder reactor cores. Studies have been performed for hybrid systems, accelerators and reactors, and fuel design studies include homogeneous fuels and nonhomogeneous fuels. And of course also there has been some previous transmutation experiments are analyzed in terms of transmutation efficiencies.

(Slide) May I have next slide, please?

Now these transmutation studies have, in terms of core calculation, similarities with the important program which is the Enhanced Plutonium Consumption Program in Fast Reactors, and this program in French we call the CAPRA program. This is also performed in the Nuclear Reactor Division and it uses two kind of cores and fuel design.

The first core and fuel design is based on classical mixed oxide fuel with a Plutonium content increased to 45 percent of plutonium, and this allows net plutonium consumption up to 70-80 kilograms per TWh. These are the figures which were quoted in Mr. Mandil's speech, talk.

Now you can have more advanced solutions based on plutonium fuel without the Uranium components, since the uranium component is what creates plutonium in a reactor, in which case the consumption can be increased to 110 kilograms per TWh electrical. You have to replace the uranium content with what we call "transparent additives," in which case you can use ceramics. I have used a few in French language and scientific language. We call them the "cercers." Or, you can have also absorbing additive, a metallic matrix based on chromium with tungsten additives, and we call these in French language the "cermets."

Now the CAPRA Program has a feasibility study phase which ends in 1994 where neutronics, safety, and fuel will be studied, and this is to be followed by a second phase.

(Slide) Next slide, please.

Yes. The second phase of the CAPRA

Program, which starts from 1995 onwards, there will be experiments in Superphenix with two CAPRA type assemblies and there will be one assembly which will be including pins for homogeneous burning of neptunium. So, separate neptunium, transform it into oxide, mix it homogeneously. Now obviously this is a research program, so only one or a few pins, not a complete assembly, of course, will be tested.

The international cooperation in the CAPRA Program is also listed, the European partners of the fast reactors, that is the English teams and the German teams, but also Italian teams at ENEA, some people from Switzerland, PNC from Japan, and also a Russian team from Obninsk.

(Slide) Can I have next slide, please?

Now for waste conditioning and storage, as Mr. Kaluzny has told you in his speech, underground laboratories are under ANDRA responsibility and CEA participates in the definition of experiments to be performed, small scale mock-ups, source term calculations, geochemical models. And also, these geochemical models have to take into account thermodynamic properties of actinides, so we measure these in special labs.

The second research line in the waste

conditioning and storage program includes improvements for conditioning and have an intermediate storage of waste. The first thing to do, and this was also stressed in Mr. Kaluzny's speech, is the characterization of waste objects. As an example, I have listed up there the characterization of compacted hulls. And there are also research lines to improve conditioning techniques, again minimization of the source term, demonstration of durability for several hundreds of years -- the point that degradation products will be innocuous, that is quite important -- and also retrievability has to be taken into account.

Now for the back end of the fuel cycle, research programs at CEA are funded at the approximately one billion French franc level, that is $190-200 million American dollars, and finance, the budget, comes from government subsidies and also money paid from industrial operators, COGEMA, EDF, and a small amount from ANDRA.

(Slide) May I have next slide, please?

We have reached the end of the back end of the fuel cycle and when --

CHAIRMAN SELIN: May I stop you?

MR. CAMARCAT: Yes.

CHAIRMAN SELIN: I have a question.

There's been some interest in amorphous matrices instead of using glass. The Australians have the cimrock (phonetic) process. The Russians are doing some research. Do you see any benefits in that? Not so much from a research point of view, but, if this process is successful, would it change either the characteristics or the cost of the back end in any significant fashion?

MR. CAMARCAT: I would say it's too early to answer. As you've seen, the law says research is being pursued until 2006, so the question you're asking is basically the results of the research program so far.

CHAIRMAN SELIN: Well, you're supposed to know the answer.

MR. CAMARCAT: No, no. Otherwise, the research would not be done.

CHAIRMAN SELIN: Another difference between our countries.

MR. CAMARCAT: If you knew the answer on an industrial scale, why do the research?

CHAIRMAN SELIN: Because it reduces uncertainties.

MR. CAMARCAT: Okay.

CHAIRMAN SELIN: Fine. Thank you.

MR. CAMARCAT: Shall we come back to the front end of the fuel cycle?

CHAIRMAN SELIN: Yes, please.

MR. CAMARCAT: So this is uranium enrichment using the SILVA process, similar to what in your country you call AVLIS, same acronyms but the wording is different. For us it has to be for the long-term industrial replacement of the Eurodif plant, which I recall was commissioned in 1981. And these plants have a lifetime of at least 30 years, so for us replacement has to be envisioned beyond 2005, so it's not a short-term program.

And if you want to think about long-term, you have to be able to reduce enrichment costs by at least a factor of two and this has to be done using the SILVA assets, which are the selectivity of laser light instead of having 1,400 stages like in gaseous diffusion. You enrich only in one step, so that gives you modular plants. You can start at a million sous (phonetic) instead of 10 million sous like in Eurodif, and also you have low energy consumption which is a major factor in the price of sous.

As an intermediate objective of the program, we have to demonstrate by 1997 the technical and economic feasibility of the process. We have two

major lines of research in terms of programs and facilities: one which is the development of technological components in Pierrelatte, and I have listed a few facilities; and the other one is the integration of the 1993 design capabilities in an integration system which we call ASTER, A-S-T-E-R, and which is located in Saclay.

(Slide) Next viewgraph, please.

This is basically the same information, but this is done on a schedule. The basic studies for model physics and basic process studies was started in 1985 and between 1990 and '95 we had the process demonstration phase which resulted in integration of the functions and enrichment products of the order of, let's say, ten grams, so it's a small scale. In 1992 onwards to 1997, a technological development phase, much greater scale components, as I've said, in Pierrelatte, and also building of the integration system, ASTER, and this goes to the general assessment of the program by 1997.

Now, all the research which is before 1997 is firmly contracted with COGEMA. On this viewgraph, what goes on beyond 1997, production demonstration and industrial deployment around year 2005, this is in discussion. This is not yet firmly contracted and of

course it does depend on the results of the 1997 general assessment.

This concludes my -- oh, one figure for the front end of the fuel cycle. Research money in 1994 is about 430 million French francs, which is around $80 million American dollars.

This concludes my talk. Thank you very much, ladies and gentlemen.

CHAIRMAN SELIN: Thank you.

Did you have some closing remarks, because, we have some general questions we would --

MR. MANDIL: I have no closing remarks.

COMMISSIONER ROGERS: I just had one, just the technological components in the Pierrelatte facilities. What are they? Can you describe what they are?

MR. CAMARCAT: Oh, yes. Yes, definitely.

Major components for the separator, the program, are the gun to produce the electron beam, the reflux parts of the separator which allows your liquid uranium to reflux the crucible, and also the extractor. This is on the separator side.

Now on the laser side we have development of a couple lasers up to 400 watts, and this is done by an industrial contractor which is CILAS, and the

program, this particular program is managed by the Pierrelatte team.

COMMISSIONER ROGERS: I see. I was amused by the names of Egyptian gods, but not all of them, I take it.

MR. CAMARCAT: Yes. This is a French custom.

CHAIRMAN SELIN: Dates only to the time of Napoleon.

Did you have something else?

COMMISSIONER ROGERS: No. That's all. Thank you.

COMMISSIONER de PLANQUE: I have no further questions. I would just like to thank you very much. It's been an excellent presentation.

CHAIRMAN SELIN: I have no questions, but I do have some remarks.

First of all, we are very pleased that the team was able to come and that you were able to assemble a group that could speak so authoritatively about such a large range of subjects.

The second is I would like to stress that this isn't so much an attempt to understand why the French program is the way it is in France, it's to understand the elements so that when we speak to third

countries we can separate that which is specific to the French situation and that which is more general. We are not trying to export our own philosophy when people ask us for advice. We really do try to learn from everybody's experience, not only from our own, and the French program is an elegant program. It's a complete program, starts from a different philosophy, but it has all aspects covered and so it's a wonderful opportunity to learn about an alternate universe, to use a heuristic approach in the language.

And the third thing I would like to do is I would like to -- we've had excellent cooperation with all aspects of the French nuclear program, whether it's the fuel cycle discussed here, the regulatory areas that we've discussed before, the reactor side or the production of electricity. But one place we have not done very much, and I would like to continue this discussion quite a bit, has to do with the economics of reprocessing so that we can in fact understand in some depth what is special and what is general, where there are formulas, how much weight you are putting on the salvage value of the Uranium as opposed to the processing questions, what would be different if the geology of the third country is different, and even some of these research questions.

A more serious answer to Mr. Camarcat's question is when one does industrial research you do have an idea of what the potential benefits are. You're trying to test them. It's not advanced research. We do know that if the scaling up is according to the formulas we have some idea of what the benefits of the cost are.

And in looking at the research programs we would very much like to benefit from the analyses that you've done on some of these new technologies. The SILVA or AVLIS is one because that's of great interest to the United States, but some of the more exotic technologies where we don't have any real experience in the United States as well.

So, we do thank you very much. I hope that this will be the first of many steps of enhanced cooperation in the fuel cycle comparable to what we have on the reactor and on the general regulatory side, and we've very pleased to welcome you here for the first time, Mr. Mandil, so thank you very much.

MR. MANDIL: And thank you for a very interesting discussion. Of course, I will tell you further, but we welcome all of your Commission very well and as often as you want to see and to have discussions with us in France.

CHAIRMAN SELIN: Thank you. We have a great deal of respect for your technical skill, but we are in complete awe of your political skills and how you work with the general public.

Thank you.

(Whereupon, at 11:48 a.m., the above-entitled matter was adjourned.)

CERTIFICATE OF TRANSCRIBER

This is to certify that the attached events of a meeting of the United States Nuclear Regulatory Commission entitled:

TITLE OF MEETING: BRIEFING ON FUEL CYCLE AND WASTE MANAGEMENT ACTIVITIES IN FRANCE

PLACE OF MEETING: ROCKVILLE, MARYLAND

DATE OF MEETING: JULY 19, 1994

were transcribed by me. I further certify that said transcription is accurate and complete, to the best of my ability, and that the transcript is a true and accurate record of the foregoing events.

Carol Lynch

Reporter's name: Peter Lynch

R&D for the back and front end of the Nuclear Fuel Cycle

N. Camarcat, CEA, France

CEA

R&D for the back end of the nuclear fuel cycle

- **Organized to answer the 3 items in the law voted 12/30/91**
  - 1-Separation and Transmutation of **actinides** and long lived fission products
  - 2-Waste storage in deep geological repositories
    - building of 2 underground laboratories
    - parliamentary decision to be made in 2006
  - 3-Improvement of processes and conditionning to store waste for long periods at ground level, including present volume reductions
- **R&D paid by government and industrial operators (Edf, Cogema, Andra)**

CEA

Reprocessing, Recycling, Waste Management

- **Long Term Objectives**
  - 1-Environmental Considerations
    - Dose Reduction, Reduce Waste in volume and activities
    - the 3 items of the law voted december 1991
  - 2-Optimal use of energy intensive raw materials
    - management of Plutonium and reprocessed Uranium
  - 3-Cost reduction for the back end of the fuel cycle
    - Improvements of the actual processes
    - replacement by new processes and equipments
  - 4-Integration of new developments and ideas to outline reprocessing in 2015
- **Short and Intermediate term objectives**
  - Technical and scientific support to plants in operation, in the start-up phase or in the building phase : UP3, UP2-800, MELOX, Rokasho-Mura (Japan), Surface Storage Center (Soulaines)

Separation and Transmutation : the SPIN program

- **PURETEX-Reduction of reprocessing Waste with COGEMA**
  - target 1995 0,9 m3/tU (suppression of bitumen, various kinds of glasses for different categories of waste...)
  - target 2000 0,5 m3/tU
- **ACTINEX-Separation of actinides and long lived fission products (longer term goal of the 1991 law)**
  - Actinides with new solvents : Coextraction of Am, Cm, Ln with diamex solvent at lab scale in 1995. It is to be followed by the the separation of Am+Cm from lanthanides. If necessary, oxydation of Am to separate from Cm. Actinide oxydes mixed homogeneously in the fuel and recycled.
  - long lived fission products extracted with macromolecules (cyclic molecules with N,O,S atoms, calixarens......)

CEA

Enhanced Plutonium Consumption in Fast Reactors-the CAPRA program

- performed in the nuclear reactor division
- Core and fuel design based on mixed oxyde fuel with a Plutonium content of 45%- Net Pu Consumption : 70-80 kg/TWh-electrical
- More advanced solution based on Pu fuel without U- Net Pu consumption increased to 110 kg/TWh-electrical
    - Transparent additives : Ceramics MgO, MgAl2O3....."Cercers"
    - Intermediate absorbing additives : metallic matrix Cr, Cr-W..... "Cermets"
- Feasibility study phase : till the end of 1994 (neutronics, safety, fuel.....)
- Second phase from 1995-onwards : Experiments in Superphenix with CAPRA type assemblies and one assembly containing pins for homogeneous burning of Np.
- International cooperations : European partners of EFR, Paul Scherrer Institute (Switzerland), PNC (Japan), Obninsk russian team

CEA

19/7/94

Transmutation Studies the SPIN/Actinex Program

- Work performed in the nuclear reactor division
- Optimisation of reactor cores for transmutation (PWR's and Breeders)
- Studies for hybrid systems accelerators, reactors
- homogeneous and inhomogeneous fuel design studies
- analysis of transmutation efficiencies from previous irradiations in Phenix and preparation of new irradiations for Np, Am

CEA

Waste conditionning and storage

- **Underground laboratories under ANDRA responsibility**
  - Cea participates in the definition of experiments to be performed (mock-ups, source term calculations using geochemical models, measurements of actinides thermodynamic properties)
- **Improvements for conditionning and interim storage of waste**
  - Caracterisation of waste objects
    - preliminary specifications of the objects for underground strorage (1995). (R&D guide)
    - caracterisation of compacted hulls
  - Conditionning techniques will be improved to
    - minimise the source term
    - demonstrate durability for several hundred years
    - demonstrate that the degradation products are innocuous
    - take retrievability into account

CEA

Waste Conditionning and storage (2)

- **examples of conditionning improvements**
  - new glasses or ceramics for medium activity waste
  - synthetic phosphates for non transmuted long lived elements (Cs, I, Cm)
- **Examples of research of new processes to treat and condition waste**
  - dose and volume reduction
  - solid waste burning with plasma torch
  - liquid waste : macromolecules for better extraction

Uranium Enrichment using the SILVA process

- **Long term industrial replacement of Eurodif plant commissionned in 1981**
- **beyond 2005, reduce enrichment costs by at least a factor 2 using the SILVA assets :**
    - selectivity of laser light, modularity of the plants and low energy consumption
- **Intermediate objective : demonstrate by 1997 the technical and economic feasibility of the process**
    - by developing technological components in the Pierrelatte facilities : Maeva, Horus, Apis, Anubis, Amon
    - by integrating the 1993 design capabilities in the ASTER integration system

CEA

The Intermediate Term SILVA Research Plan

- By 1997, demonstrate the technical and economical feasibility of the SILVA process
  - *Basic studies* : physics, models and process optimization
  - *technological facilities* : development of components at significant scale
  - *integration facilities* : photons and Uranium vapor and all process functions at a not too expensive scale
  - *plant lay out studies* and economics
- R&D partnership with COGEMA, other industrial participants include : CILAS, GEC-ALSTHOM, SNECMA......

CEA

19/7/94

Washington D.C., July 19, 1994

The Nuclear Fuel Cycle Policy of France

Claude Mandil
Director of Energy and Natural Resources

It is truly a pleasure for me to be here today to present France's nuclear fuel cycle policy to the Commissioners of the Nuclear Regulatory Commission.

I - The Status of Nuclear Energy in France

France's nuclear program currently consists of 54 pressurized water reactors, all based on standard designs. These units have an installed generating capacity of close to 60,000 MWe and generate over 75% of France's electricity. Since 1993, the units have operated with a greater than 80% availability factor. Four more units are under construction (Figure 1).

II - Waste Management Policy

Ninety percent of the nuclear waste generated in France is short-lived and low- and medium-level waste. This waste is disposed of at the Centre de la Manche and the Centre de l'Aube facilities operated by Andra. The Centre de la Manche facility is full; the last waste deliveries were made this month. The Centre de l'Aube has enough capacity to cover disposal requirements for the next forty years. This type of disposal facility has never raised any problems, either in terms of the technology or in terms of public acceptance.

Our approach to long-lived waste is defined by the Waste Act of December 30, 1991, which was passed almost unanimously by the French Parliament. The law requires that research on long-lived and high-level waste management be divided into three areas:

- separation and transmutation of long-lived radioactive elements;

- the potential for disposal in deep geologic formations through construction of underground research laboratories; and

- surface storage of waste and the containment issues that this raises.

These research programs are well funded by the government and the waste generators. In 1994, spending on the three research programs will be approximately 260 million, 500 million and 170 million francs respectively.

The Waste Act requires that the research findings be presented to Parliament in fifteen years, accompanied by a draft repository licensing bill if the findings so dictate. Mr. Kaluzny and Mr. Camarcat will discuss the work being conducted in the framework of the Waste Act in more detail.

III - Reprocessing, Recycling and Plutonium Management

However, one does not need to wait for the outcome of these research programs to know that radioactive products requiring isolation for thousands of years must be minimized if future generations are not to inherit veritable mines of plutonium and long-lived radioactive waste. In fact, plutonium will still represent 95% of the radiotoxicity of the spent fuel after 10,000 years.

Reprocessing and recycling of fissile materials help to achieve this goal. Plutonium from spent fuel reprocessing may be recycled in pressurized water reactors as Mox fuel or in fast breeder reactors in either a breeding or an incinerating mode. Recycling saves energy supplies and natural resources. In addition, reprocessing makes it possible to solidify the minor actinides and fission products--the only real waste, devoid of energy value--into forms suitable for final disposal.

To prevent separated plutonium from being stockpiled, EDF reprocesses its spent fuel only when it has a specific use for the separated plutonium. Therefore, how much fuel is reprocessed is not just a function of reprocessing plant capacity, but also of Mox fuel fabrication capacities and reactors licensed to use Mox fuel.

2.1 - Recycling with Mox Fuel

The Melox plant at Marcoule, scheduled to start up in 1995, will be capable of fabricating 120 tons of Mox fuel from the 8 tons of plutonium that the UP2-800 reprocessing plant at La Hague can produce each year. One hundred twenty tons of Mox fuel corresponds to nearly twenty reloads. Six reactors are loaded with Mox fuel at the present time. This number will gradually rise to around twenty by the end of the decade, and possibly more later.

A reactor loaded with Mox fuel produces plutonium and consumes it at the same time. Currently, a reactor loaded with Mox fuel produces a total of 60 kilograms of plutonium per year, while a reactor loaded with conventional fuel produces 230 kilograms of plutonium per year. Research is under way to reduce the net plutonium production of a reactor loaded with Mox fuel further, or even to make it a negative value.

2.2 - Recycling in Fast Breeder Reactors

Similarly, research is in progress to study the potential for incinerating plutonium in fast breeder reactors. This is the subject of the CEA's Capra program, in which several countries are participating, including Japan. Superphenix will restart in a few days for this purpose.

Depending on the results of this program, we could ultimately foresee a mixed reactor program that combines pressurized water reactors operating with conventional fuel or Mox fuel and fast breeder reactors. This would allow us to stabilize our plutonium inventory, whether or not the plutonium is separated.

* *
*

In conclusion, I would like to say that our use of plutonium in the nuclear power program is already a commercial reality that meets our needs in terms of natural resource conservation and environmental protection and that does not raise proliferation concerns because it is properly safeguarded by international organizations such as the International Atomic Energy Agency.

Plutonium is produced by reactor operations, not by reprocessing. Reprocessing is a relatively simple chemical operation that merely separates plutonium, but it requires impressive facilities to protect operating personnel from radiation and to protect the environment. Some power reactors, such as the Canadian Candu reactor, permit continuous discharge of low irradiated fuel capable of supplying weapons grade plutonium. These reactors are therefore intrinsically more proliferating than pressurized water reactors and the reprocessing plants that serve them.

Lastly, countries that have proliferated in recent years via the plutonium "path" have done so with materials from continuous discharge reactors or from research reactors. In no case have pressurized water reactors, fast breeder reactors or commercial reprocessing plants safeguarded by the IAEA been implicated.

In this regard, there is no need to tighten safeguards on nuclear facilities already safeguarded by the IAEA, nor is it necessary to adopt international plutonium management measures. However, it is certainly essential to show greater openness and to explain how plutonium is used by the civilian nuclear industry and in what amounts

We will now show you a film to illustrate my remarks. I will then turn the floor over to Mr. Ricaud, Mr. Kaluzny and Mr. Camarcat, who will explain the points I have raised in greater detail.

MAIN ISSUES OF THE BACK-END OF THE FUEL CYCLE

Jean-Louis RICAUD

COGEMA

NRC **July 94**

MAIN ISSUES OF THE BACK–END OF THE FUEL CYCLE

J.L. RICAUD
COGEMA
Vélizy Villacoublay - FRANCE

INTRODUCTION

All human activities consume natural resources and produce waste. Man has made increasing use of fossil energy and mineral resources which will ultimately be depleted and, to a certain extent transformed into waste products polluting the environment and having a detrimental impact on the global climate (acid rain, greenhouse effect). For illustration, in a current nuclear reactor, an annual electric energy output of 6.6 billion kwh, produced by 21 tons of PWR fuel at a burn–up of 43 GWd/t, corresponds to the burning of 2 million tons of coal in a conventional power plant releasing 120 000 tons of ashes, 5.4 millions tons of CO_2 and 50 000 tons of SO_2.

In the recent years, there has been a growing interest for recycling in all industrial activities, as making good environmental sense, fully embraced by the public at large. Recycling is seen as a wise strategy in general, whose economics must be assessed with regard to the specificities of each industry.
It should then be surprising that a number of "environmentalists" which see themselves as ardent supporters of all recycling schemes, are opposed to the nuclear industry's recycling plans. Plutonium in particular is the centerpiece of many complex and biased debates, attempting to diabolize this energetic resource.

The fact is that the nuclear industry and scientific community, aware of its social and long–term responsibility, has been a leader since many years in pursuing reprocessing/recycling as a resource management strategy to recover plutonium and uranium safely, recycle them (an indisputable benefit in terms of long–term energy availability), minimize the volume of final wastes to be disposed of, reduce the waste toxicity thus protecting the environment.

The stake of recycling in terms of clean energy production must be put in global perspective : the world nuclear power reactors produce today 50 tons of plutonium per year. Recycling this resource would represent an electricity amount equivalent to up to 100 MTOEs per year, the oil production of Kuwait ; adding uranium recycling, the global potential of recycling fissile materials arise to 150 MTOEs per year, which is comparable to the 180 MTOEs per year production of all the oil fields of the North Sea.

This paper describes the present situation of the reprocessing/recycling industry, mainly through the experience of COGEMA, and discuss the main trends of the recycling route through waste volume reduction, MOX usage, economics and non–proliferation issues.

A DEMONSTRATED INDUSTRY

Reprocessing operations

The COGEMA La Hague reprocessing plants whose capacity is 1,600 tons per year of LWR spent fuel, shows very high levels of performance regarding product quality, radiological impact and occupational exposure. Actual operating experience put personnel average exposure at less than 0.43 mSv in 1993, well below the level of natural radioactivity, and there is every reason to believe that this performance will continue.
The products : uranium and plutonium, meet all quality requirement, and the various waste forms produced at La Hague have undergone a stringent waste acceptance process and are licensed by regulatory authorities of France, Japan, Germany, etc...

Waste volume reductions

For the La Hague UP3 plant, improvements to waste treatment methods will result in greater waste volume reductions, when bituminized waste forms (450 liters per ton in 1991 and 100 liters per ton today) are to eliminated completely by 1995. Regarding metallic and technological waste, the introduction of new technologies : compacting and incineration, will give in a few years, a volume reduction factor up to five.
Current waste volume goals are shown in the following table.

La Hague Waste Volume Reduction : General Goals

	Nominal	Actual 1994	Anticipated 1995	Anticipated 2000
Waste which does not meet current French near-surface disposal requirements	3 m^3/MTU	1.06 m^3/MTU	0.9 M^3/MTU	< 0.5 M^3/MTU

This non-surface waste volume reduction program has led to a performance level already less than the Swedish announced estimation for the direct disposal technology. In a few years, these reprocessing waste will represent only 0.5 m^3/MTU, one-third of the corresponding direct disposal figure.

Recycling, the MOX fuel use

Recycling is the indispensable natural complement to reprocessing : after spent fuel components efficient separation and waste conditioning, the valuable fissile materials : plutonium and uranium are available to produce energy.
Today, of EDF's 55 reactors in service, seven are loaded with MOX fuel. EDF plans to extend such MOX fuel use in most of its twenty eight 900 MWe PWRs by the end of the century.
Regarding reprocessed uranium, EDF is also engaging in a full-scale recycling scenario.
MOX fuel design continues to be improved, particularly in terms of burn-up. In France, the MOX operating licence already allows a maximum burn-up at 39 GWd/t for a third core fuel reload cycle and in the near future, MOX fuel performance will be brought to the highest levels currently achieved with uranium fuels which have an average burn-up of 45 GWd/t.

To respond to the utilities engagement in MOX fuel use, a new MOX fuel fabrication capacity is to be added to the current European facilities : Dessel (BN) and Cadarache (COGEMA), with the completion of the MELOX plant, to start up in 1995, with a capacity of 120 tonnes per year, able to increase in the following years.
To keep pace with the growing global use of MOX, other large-scale MOX fuel fabrication plants are under project or construction in Europe and Japan : shortly after the turn of the century, a worldwide MOX fuel fabrication capacity of 400 to 500 metric tons per year will be in place, which will enable to recycle up to 40 metric tons of plutonium annually.
Then, for the next future decades, the fuel cycle industry has undergone the assessment of further strategies with multiple plutonium recyclings and growing plutonium in-core percentages, to provide for the best optimized plutonium management, incorporating possibly new reactor types.

This global energy strategy of reprocessing and recycling, key to the sustainable development of the nuclear power option, provides considerable advantages in terms of reduced long-term waste inventory, volumes, radioactivity and radiotoxicity compared with the direct disposal alternative.

ECONOMICS

The economics of the back-end of the fuel cycle is always a subject of heated debate for several reasons :

i) The overall objective of plutonium recycling should be unambiguously exposed :

- Either one considers that the plutonium is a highly toxic material, which cannot reasonably be disposed of as such. In this case one should admit the reprocessing/recycling strategy which recovers 99.9 % of the Pu included in the spent fuel, in order to burn it and transform it into electricity. Such strategy has a well-known, industrially demonstrated cost, and has benefits which must be expressed both in monetary and extra economics terms.
- Or the definitive storage of plutonium is environmentally and strategically accepted and in such case direct disposal of spent fuel may be envisioned, even if not currently available.

Such questions should be raised clearly in each country engaged in nuclear energy, with possibly a different answer according to the general policy of such country in terms of energy and environment.
But a paradoxical situation arises when some so-called environmentalists insist at the same time on a specific toxicity of plutonium, recommend the direct disposal, and are opposed to recycling on economic grounds, pretending moreover that this incoherent reasoning is valid for all countries !...

ii) This being clarified, one should then discuss the applicable economic valuation methods for comparing reprocessing/recycling and direct disposal :

- Cost comparisons between alternative processes and technologies can only be made on the basis of equivalent services. It has been shown above that this is obviously not the case when comparing the reprocessing/recycling scenario with the direct disposal option, both in terms of global energetic strategy and of ultimate waste disposal.

- It is well known that standard accepted economic calculations are dependent on assumptions about the economic life and technical performance of the physical assets, on the appropriate rate of return on capital, on fuel and operational costs over time, etc. Discounted cash-flow analyses involving periods several decades long systematically favor scenarios in which

capital investment and operating expenses are postponed, even when the amount of these investments and expenses has not yet been established.
This is because the discounted cash–flow method reduces their present value to negligible amounts compared to capital investment made today. It is useful to realize that in terms of present value, 1 FF now is valued as more expensive than 100 FF in 60 years. This obviously introduces a bias in favor of no decision scenarios.

In light of these observations, it is rewarding to comment on the conclusions of the most recent study on the costs of various options in the back–end of the fuel cycle by the Nuclear Energy Agency of the OECD, in which a dozen countries and international organizations participated :

i) With the same sequence of expenses, the two alternate fuel cycles present very close results in term of costs per kWh.

ii) The only reason for the reduction of the direct disposal cycle cost is the mathematical effect of the discounting method, which may have a devastating demotivation effect on the rational planning of future investments.

iii) The reprocessing/recycling costs are completely controlled as established commercial prices, while direct disposal costs are only preliminary estimates, which can only rise when industrially demonstrated.

iv) Observing the industrial situation in Europe shows that almost all the investments for the reprocessing/recycling cycle have been already done, to compare with the direct disposal option where 90 % of the expenses still need to be done. As a consequence, comparative cash–flow analyses would usefully complement the usual economic approach and favor the already industrially implemented solution.

v) Finally one must well understand the size and structure of the respective costs of fuel fabrication : in a MOX fuel fabrication plant, two–third of the production costs are associated with investment, to be progressively amortized in the next coming years, while the UO2 fuel fabrication plants are already almost written–off.
Taking all this into account, the OECD final discounted cost shows only a 10 % difference between the two options, which can only be reduced in the near future, due to the developments in progress in the recycling industry.

NON PROLIFERATION

For the knowledgeable, honestly concerned community, the history of the past twenty years shows that proliferation is not simply a matter of plutonium on one side and everything else on the other. In fact, when some vocal people ask for banning reprocessing as the essential component of a non–proliferation policy, they tend to forget that :

- plutonium from current electronuclear reactors (LWRs) is not a weapon–grade quality material ;

- today, uranium enrichment technology, not reprocessing/recycling, might be the easiest pathway to nuclear weapons ;

- there is no example of a nation attempting to divert safeguarded plutonium or use plutonium recovered from commercial LWRs to acquire nuclear weapons capability. In fact all attempts to

acquire a nuclear weapons capability have centered on clandestine operation of non–safeguarded facilities ;

- commercial reprocessing and MOX recycling is an indispensable step to control now the plutonium generation as each recycling scheme decreases both the residual quantity of plutonium and its isotopic quality.

The fact is that commercial reprocessors are firmly committed to the peaceful use of nuclear energy, as demonstrated over the past 30 years. They operate under transparent safeguards arrangements, appropriate international controls and strict procedures which permit the safe and secure management of plutonium.

CONCLUSION

The future of the nuclear fuel cycle will certainly differ from one country to another. Those can afford expensive natural resources may decide for political reasons to curtail their nuclear programs and adopt the once–through option. Others will master and develop their nuclear programs and implement a closed cycle.
In both cases, the choice for the back–end proceeds from a national policy, combining energy and environmental considerations.

The once–through option or the "wait and see" attitude strengthen people's feeling of unresolved waste management issues and do give a bad impression of wavering in front of the rational use of energy resources and waste minimization issues, whereas the advancing reprocessing and recycling industry gives a more persuading evidence of capability. Moreover, it is not wise to treat plutonium as a waste and throw it away ; human societies usually are incline to forget things that are considered of no value, and in the long term, such an attitude might give rise to more serious risks of misuse or harmful impacts than a conscious, well controlled and steady management of plutonium.

The reprocessing/recycling strategy, by enhancing the safety, reliability and economic viability of the fuel cycle and ensuring the long–term growth of the nuclear power, is the guide to a modern and sustainable industrial development.

PRESENTATION OF ANDRA
to
U.S Nuclear Regulatory Commission

July 19,1994

Y.KALUZNY

Andra was created to manage radioactive waste. We consider ourselves to be "environmentalists" whose task is to manage waste in a safe and suitable manner to protect the environment now and in the future. We know that waste management not only requires technical and scientific answers but that it must integrate in a pragmatic approach science, society, psychology and politics.

My presentation will be focused on three main lines :

- A the implication of politicians and elected people
- B the technical works and studies
- C the monitoring and control of ANDRA's actions.

A) **Politicians and elected people involment.**

A.1 In the late eighties, we had a negative experience in trying to investigate four potential repository sites. In February 1990, after heavy public contest, the government declared a moratorium of "at least one year" on Andra's field work.

Immediately thereafter, a new decision-making process was begun, one designed to restore confidence and to be as open as possible, to provide guarantees for each step of the process.

Following substantial work involving public hearings, the French Parliamentary Committee on Science and Technology issued several reports concluding that the societal aspects of waste magagement were to be handled by the Society, represented by the Parliament and the elected people ; finally, the Waste Management Research Act was passed on December 30, 1991.

A.2 Members of Parliament were very concerned by radioactive waste questions. The Act was voted by a very wide majority.

Moreover, the Act and its application decrees set up 3 important dispositions :

a) to open widely the fields of research : to reduce radiotoxicity of waste by partitioning and transmutation; to evaluate and assess "in situ" through the use of underground laboratories the possibility of disposing long lived radioactive waste in deep underground host rocks; to improve waste conditioning for long term interim storage.

b) the foreseen laboratories will only be set up in communities which are volunteer candidates.

c) the establishment of ANDRA as a public Agency and the control of ANDRA's action.

To raise up volunteer candidates, a Member of Parliament, Mr.Bataille, has been appointed as a Mediator charged with identifying sites for two underground laboratories. Mr Bataille was confirmed by the new French government elected in March 1993, giving the evidence that in France the waste problem is an apolitical and national one transcending party politics. Mr. Bataille proposed four Departments, representatives of which had voted in favor of hosting a laboratory after the project has been presented by the Mediator. None of them were from the four sites where work was interrupted by the 1990 moratorium, which goes to show how difficult it is to reverse strong political positions adopted under intense public pressure. Local elected and association people will constitute local information Committees, enhancing the involvement of people living in the surroundings.

A.3 Politicians also consider that their responsibility is engaged in establishing suitable and adequate systems aiming at monitoring and controlling how the organisation in charge of waste management is performing the assigned mission. I will detail this point later.

B) Actual on site situation

Following the conclusions of Mr Bataille's report at the end of his mediation mission, the government decided to allow ANDRA to start a detailed geologic review in four departments (map) namely :

Gard near Bagnols sur Cèze,
Haute Marne near Chevillon,Poissons,Joinville,Doulaincourt, Saucourt, Saint Blin Semilly
Meuse almost the whole territory
Vienne near Charroux and Civray.

The agenda is now as follows:

Designation of the mediator	December 1992
Phase 0-Mediator mission	1993
Agreement on the proposed departments	January 1994
Phase 1-Local prospection and selection of sites	1994- 1995
Phase 2-Application for the building and operating licence	
Public enquiry for two laboratories	1996
Phase 3-Building and research in the labs	1998 2005
Phase 4-Assessment of research	
Proposal from ANDRA on disposal concepts	2006

Today, we are proceeding the first phase with the objective of choosing the sites. Criteria are given by the Basic Safety Rule III 2 f.

C) Institutional Control

Three different types of control systems have been set up.

C.1 Control by the Parliament

The ultimate decision concerning the eventual political agreement about final repository will be taken, as written in the Act, by the Parliament through a new law. A first dead line is also proposed in the Act. A National Review Board will be in charge of submitting a report as a technical, scientific and social basis for the decision. This Board, now constituted, will follow year after year the results of the various studies launched on the three paths of research defined by the law (and not only on deep underground disposal). To do so, the Board will receive each year a synthesis report from each involved responsible organisation (ANDRA as responsible

for underground disposal, CEA as responsible for the two other ways of research, ANDRA informed of all results concerning the final product).

A Member of Parliament participating in the French Parliamentory Committee on Science and Technology (analogous to your National Waste Technical Review Board) was recently assigned a mission of follow up of the actions resulting from the Act. He will act as an external political auditor although we have not yet a clear idea of his interrelations with the National Committee.

C.2 Control by the Safety Authority

Obviously, design , building and operation of a repository will be in agreement with the existing regulation governing "French Basic Nuclear Installations". The siting of the repository is closely linked to the results provided by the underground laboratory. In that sense, the operation of the laboratories falls under the control of the Safety Authority.

C.3 Control by local involved representatives

As already said, each laboratory, and later if some decision is taken the repository, will provide open information to the local community and to their representatives in the Local Information Committees. People living near by the installations and often working inside are fully aware of every type of operation running on inside the installation. In that sense, their feelings constitute an acceptance signal and a first step of defence in depth against any wrong, unrealistic, dangerous or not announced programme or action inside the installation.

R&D for the back and front end of the nuclear fuel cycle

N. Camarcat, CEA, France

7/19/1994

Following the previous speakers, this talk will review Research & Development programs performed in France in the Cea laboratories for the back and front end of the nuclear fuel cycle. The research is funded both by the government and by the industrial operators i.e. EDF, COGEMA and ANDRA.

(Viewgraph 2) Research for the back end of the fuel cycle is organised according to the 3 goals written in the 1991 law:
1-the partitionning and the transmutation of actinides and long lived fission products.
2-The building of 2 underground laboratories to study waste disposal in deep geological repositories, in which research will be pursued until 2006. At this point, in view of the available results, the parliament will decide whether to go ahead with industrial repositories.
3-the improvement of processes and conditionning to store waste for long periods at ground level

The first topic when considered from the reprocessing point of view can be supplemented with the long term objectives outlined in viewgraph 3. In a shorter time frame, the research programs provide technical and scientific support to plants in operation, in the start up phase or in the building phase.

Viewgraph 4 outlines the 2 items of the SPIN program (partitionning and transmutation) including:
-the PURETEX line, in close association with COGEMA to reduce waste from reprocessing plants in operation.
-the ACTINEX line which answers the longer term goal of the 1991 law. Processes will be tried at the lab scale to co-extract Americium, Curium and Lanthanides from Fission Products of the present process. Neptunium can be extracted with the U and Pu partition products after an oxydation stage at valence VI using more conventional techniques. Actinides can be further separated from lanthanide like fission products, transformed into oxydes and recycled in reactors. Another route to selective extraction is the use of cyclic macro-molecules to extract long lived fision products.

Viewgraph 5 presents the reactor programs to transmute the separated actinides, using homogeneous and inhomogeneous fuels. Neptunium will be the first actinide to be transmuted experimentally by inserting specially designed pins in fast reactor cores.

The CAPRA program to enhance plutonium consumption in fast reactors is shown in viewgraph 6. "Classical" fast core designs plan to use Plutonium contents of 45% to increase Pu consumption up to 70-80 kg/TWhelectrical. More advanced designs rely on fuels without Uranium which is the primary source of Plutonium formation. Calculations show that they can increase Plutonium consumption up to 110 kg/TWhelectrical. The feasibility study phase terminates at the end of 1994. It is to be followed by experiments in Superphenix of CAPRA type assemblies.

Viewgraphs 7 and 8 show the waste conditionning and storage programs pertaining to topics 2 and 3 of the 91 law. Research is sponsored by ANDRA to define scientific experiments to be performed in the underground labs (mock-ups to simulate actinide migration at the best extrapolable scale, improvement of geochemical models coupling aqueous transport and chemistry, measurements of thermodynamic properties of actinides.......). Research programs also include improved caracterisation of waste objects so that specifications can be regularly improved both at the underground laboratory level and further. This concerns primarily B and C class waste, since A class waste is stored industrially in Soulaines, as shown earlier in the film. Examples of conditionning improvements include new glasses or ceramics for medium activity waste (replacement of bitumen) and synthetic phosphates for non transmuted long lived elements (Cs, Cm, I....).

The last 3 viewgraphs outline the Uranium Enrichment research for the front end of the fuel cycle. The SILVA process is developed for long term replacment of the Eurodif Plant commissionned in 1981. Cost targets are at least a factor 2 below costs of depreciated gaseous diffusion. The 1997 milestones in the program will establish the technical and economical feasibility of the process using the technological components of the Pierrelatte facilities and the ASTER integration system in Saclay.